Electronic Supplementary Information

Inter-tube adhesion mediates a new pearling mechanism

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1. Tube deformation by inter-tube adhesion

To explain how inter-tube adhesion increases tension of both tubes, we provide the cross sections of two adhering tubes under three different adhesion strengths. According to Figure S1, the extent of tube deformation is increased by increasing inter-tube adhesion strength. Considering the volume of each tube is constant during the simulation, the tube deformation thus increases the tube surface area (because circular cross section has the smallest perimeter under constant area). As the lipid number for each tube is constant, the increased tube area thus increases tension of both tubes.

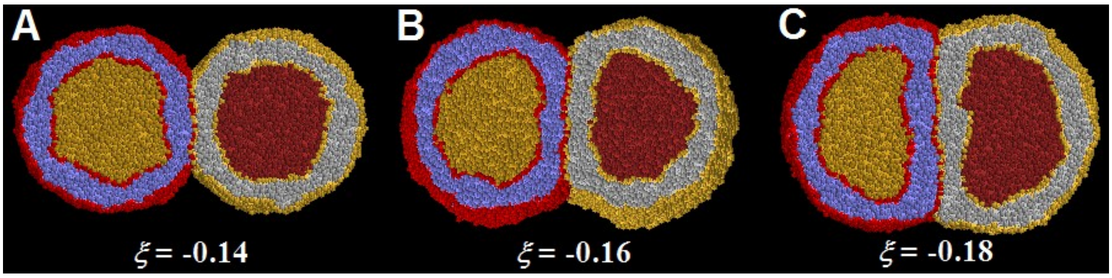

Fig. S1 Cross sections of two adhering tubes under different inter-tube adhesion strength. The interaction parameters are set to $a_{H_1H_2}$= 16 (A), 14 (B), 12 (C), respectively.

2. No pearling of two thinner tubes

In order to understand the effect of tube diameter on final pearling instability, we further decrease the tube diameters from 20 nm to 15 nm. The interaction parameter representing inter-tube adhesion strength is set to $a_{H_1H_2}$= 8.0, under which two adhering membrane tubes with diameters of 28 nm both undergo thorough pearling (Fig. 3). For two thinner tubes with diameters of 20 nm, however, only partial pearling can take place. We analyzed that the partial pearling is mainly due to the early stage inter-tube lipid diffusion, which reduces the extent of inter-tube adhesion. It was thus speculated that the pearling extent may be further reduced if we further decrease the tube diameter. Indeed, for two thinner tubes with diameters of 15 nm, the inter-tube lipid diffusion is initiated at about t = 30000, which is much earlier than that for tubes with diameters of 20 nm (Fig. S2). Once the inter-tube lipid diffusion is initiated, the inter-tube adhesion is strongly restrained. As a result, no obvious pearling is observed during our simulation.

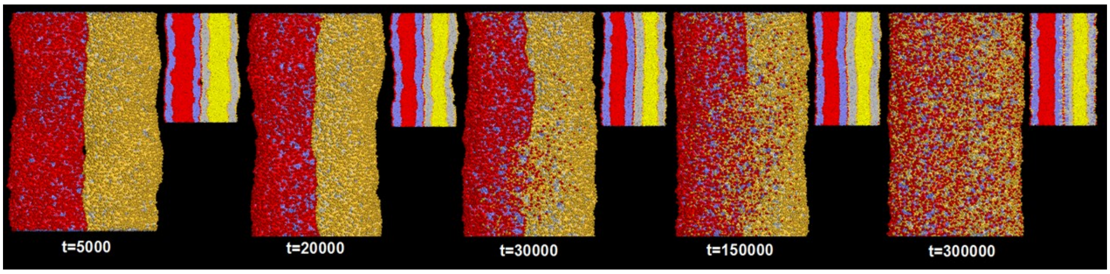

Fig. S2 No pearling of two thinner adhering membrane tubes. The initial tube diameters are set to $D1 = D2 = 15$ nm. The interaction parameter representing inter-tube adhesion strength is $a_{H_1H_2} = 8.0$.

3. Size effect analysis

In order to reduce the size effect on tube pearling, we fixed the tube diameter to 28 nm and increase the tube length from 75 nm to as large as 500 nm. The typical snapshots obtained from the solvent free DPD simulations are given in Figure S3, from which no obvious tube pearling is observed. Besides, each tube undergoes a severe deformation, which suggests that the tube volume does not maintain during the simulation. We thus conclude that the pearling of two adhering membrane tubes could not be simulated by implicit solvent DPD simulation method. Nevertheless, simulations of single membrane tubes have confirmed the size effect, which can be reduced by increasing the tube length (Fig. 10).

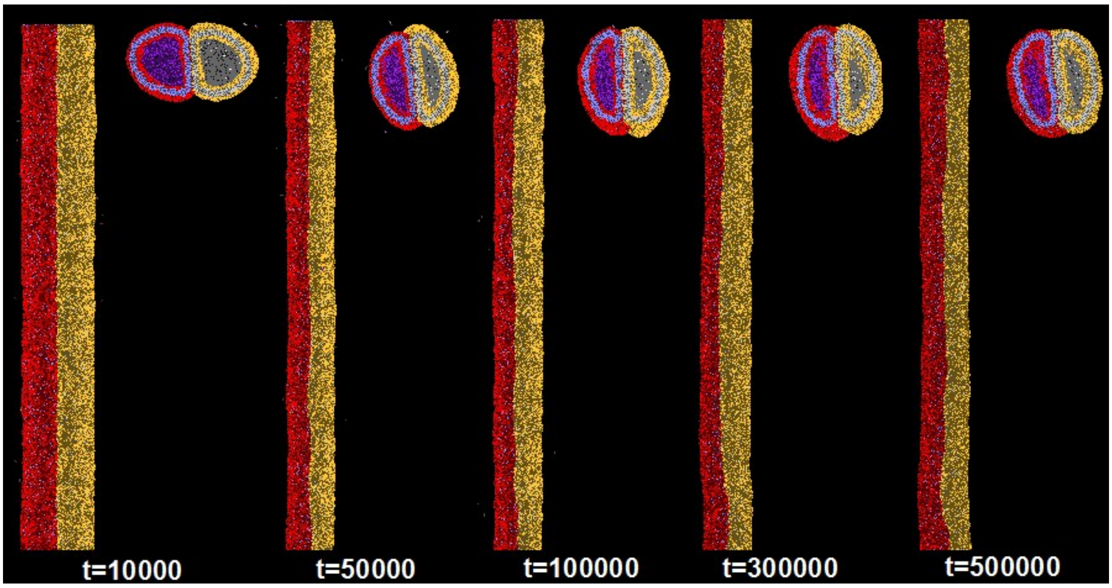

Fig. S3 Shape transformation of two long adhering membrane tubes. The initial tube diameters are set to *D1* = *D2* = 25 nm. The tube length is set to 500 nm.